PROC. ENTOMOL. SOC. WASH.
91(3), 1989, pp. 325-341

TAXONOMIC STUDY OF THE LARVAE OF SIX EASTERN NORTH AMERICAN *DIORYCTRIA* (LEPIDOPTERA: PYRALIDAE: PHYCITINAE)

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Abstract.—Larvae of six eastern North American species of *Dioryctria* Zeller were examined using both a stereo light microscope and a scanning electron microscope (SEM). Detailed descriptions and a key to the species, supplemented with electron micrographs, are presented for the last instar larvae of *D. abietivorella* (Grote), *D. disclusa* Heinrich, *D. pygmaeella* Ragonot, *D. clarioralis* (Walker), *D. amatella* (Hulst), and *D. taedivorella* Neunzig and Leidy.

Key Words: Pyralidae, Phycitinae, *Dioryctria,* immatures, coneworm, taxonomy

The genus *Dioryctria* Zeller is mostly Holarctic in distribution with a few species also occurring in the northern tropics. Fifteen species are known from eastern North America. Larvae feed exclusively on conifers.

The adults of the North American species of *Dioryvcia* have been the subject of extensive taxonomic study beginning with Heinrich (1956) and Munroe (1959). In 1969, Mutuura, working in conjunction with several others, began a series of papers following up on Munroe's work (Mutuura, Munroe and Ross 1969a, b, Mutuura and Munroe 1972, 1973, 1974, 1979, Mutuura 1982, Mutuura and Neunzig 1986). Additional work on the adults has been done by Schaber and Wood (1971), Coulson et al. (1972), Blanchard and Knudson (1983) and Neunzig and Leidy (1989).

Although *Dioryctria* larvae have been briefly covered in various publications on forest pests, detailed descriptions of the larvae are few. MacKay (1943) described and figured the larvae of *D. reniculelloides* Mutuura and Munroe (as *D. reniculella* Grote), and briefly differentiated it from *D. abietivorella* (Grote) (as *D. abietella* Denis and Schiffermuller). Farrier and Tauber (1953) described and illustrated the larvae of *D. disclusa* Heinrich, and Lyons (1957) also described *D. disclusa* as well as *D. cambiicola* (Dyar) and *D. abietivorella* (as *D. abietella*). Neunzig et al. (1964), gave detailed descriptions of six species occurring in the southeastern United States: *D. amatella* (Hulst), *D. ebeli* Mutuura and Munroe (as *D. abietella*), *D. clarioralis* (Walker), *D. disclusa, D. taedivorella* Neunzig and Leidy (as *D. zimmermani* (Grote), and *D. pygmaeella* Ragonot. Schaber (1981) published on the larvae of *D. taedae* Schaber and Wood, however, larvae of *D. taedivorella* and *D. yatesi* Mutuura and Munroe were probably included in the described material.

Only two studies of *Dioryctria* have made use of scanning electron microscopy (SEM). Bradley et al. (1982) used SEM to examine the eggs of three species, *D. disclusa, D. amatella* and *D. ebeli.* The early-instar larvae of *D. reniculelloides* were examined by Spies and Dimond using SEM (1985).

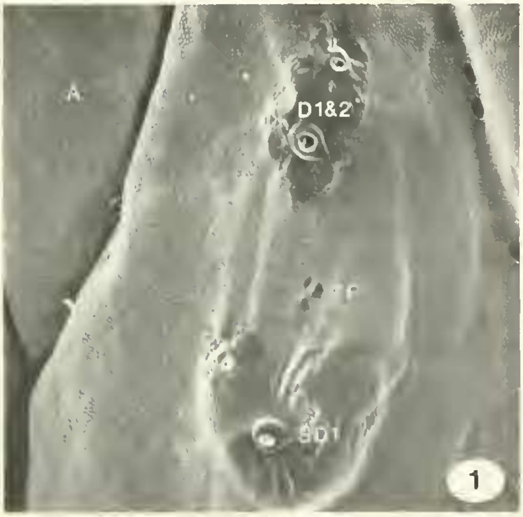


Fig. 1. Part of mesothorax including D and SD pinacula of *D. disclusa*, dorsolateral aspect. (150×). TP, tonofibrillary platelets; A, area shown enlarged in Figs. 22–27.

In this paper we update the descriptions of the last-instar larvae of six species by utilizing the conventional light microscope and the scanning electron microscope to reexamine the known diagnostic characters and to discover additional species differences.

Materials and methods.—*Dioryctria* larvae were collected in North Carolina from *Pinus taeda* L. (loblolly pine), *P. palustris* Miller (long-leaf pine), *P. echinata* Miller (short-leaf pine), *Taxodium distichum* (L.) (bald cypress), and *Abies fraseri* Pursh (Poiret) (Fraser's fir). Representative specimens of six species known to occur in eastern North America were obtained. Portions of each collection were preserved as larvae and the remainder reared to obtain adults. Descriptions of the color of the larvae were prepared immediately after fixing. The width of the head was measured at the widest point, and the length from the distal margin of the clypeus to the most posterior point of the epicranium. The median breadth of the spinneret was measured across its lateral surface.

Larvae to be examined using SEM were dissected in 40% ethanol. The head was removed, separated laterally at the point of mandible attachment, the mandibles removed, and the dorsal and ventral halves retained intact for the next several steps. Abdominal segments 9 and 10 and the left half of the thorax were also removed. The four pieces of tissue were brushed with a soft brush to remove loose debris, placed in a 50:50 solution of 10% Tween® 20 and 40% ethanol, and sonicated for five minutes. The tissue was then rinsed in 40% ethanol, brushed again, and transferred to flow-through capsules of Porex® Porous Plastic (Porex Technologies). It was then dehydrated in a graded series of ethanols (40%, 70%, 95%, 100%, 100%, 100%) and critical point dried using CO_2 in a Tousimis® Samdri®-PVT-3B. The dried tissue was then placed on studs using SPI® Conductive Carbon Paint (colloidal graphite in isopropanol 20% solids) and allowed to dry at least two days. Excess structures and tissue were removed using a hypodermic needle and all surfaces carefully brushed with a soft brush. The tissue was then coated with gold-palladium in a Technics Hummer V® sputter coater to a thickness of 25 nm, and observed with a JEOL JSM-T200® Scanning Electron Microscope (15 kV, WD 8, spot size 9). Micrographs were made using Polaroid® Type 55 P/N film. Setal nomenclature as given in Stehr (1987) is used for the body setae (Fig. 1). The terminology used for the mouthparts follows Crumb (1929) (Figs. 2, 3). The term tonofibrillary platelet is from Neunzig (1979). Terminology for the integument texture follows Eady (1968), Harris (1979), and Torre-Bueno (1978). A pair of structures on the epipharynx located mesad and slightly ventrad of epipharyngeal seta 1 were found to have not been named in the literature. They are herein referred to as epipharyngeal sclerites (Fig. 2). The margins of these sclerites are not clearly defined in electron micrographs but are generally visible under the light microscope and consistently

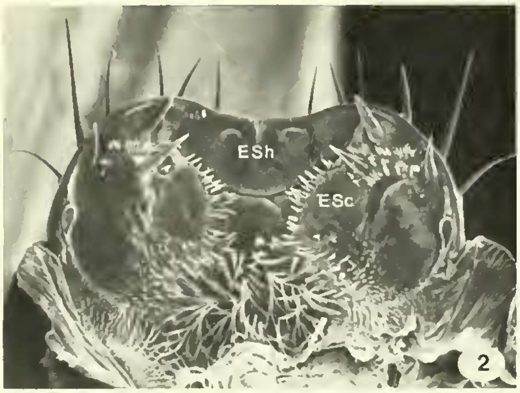


Fig. 2. Epipharynx of *D. amatella* (180 ×): ESc, epipharyngeal sclerites; ESh, epipharyngeal shield.

bare of spines, except occasionally on the mesal margin.

Common names of most species follow the Entomological Society of America (1982). The name fir coneworm for *D. abietivorella* is from Hedlin et al. (1981). Hedlin et al. (1981) also used the name loblolly pine coneworm for *D. merkeli* Mutuura and Munroe. In light of recent work (Neunzig and Leidy 1989), we suggest that the name loblolly pine coneworm would be better suited to *D. taedivorella*, as *D. merkeli* appears to feed chiefly on slash pine, *P. elliotii*. Scientific and common names of host plants follow Radford et al. (1968).

All intact immatures and adults have been placed as voucher specimens in the North Carolina State University Insect Collection (NCSU).

Dioryctria abietivorella (Grote)
(fir coneworm)
Figs. 4, 10, 16, 22, 28

Pinipestis abietivorella Grote, 1878, Bulletin of the U.S. Geological and Geographical Survey of the Territories, 4: 701.

General.—Length 19.4 mm to 21.4 mm. Head reddish brown in epicranial area, shading to somewhat darker reddish brown near mandibles and hypostoma; tonofibrillary platelets indistinct; hypostoma reddish brown; antennal segments brown; mandibles reddish brown. Prothoracic shield translucent yellowish white anteriolaterally and mesally, remainder medium brown. Prespiracular plate yellowish brown, dark brown on posterior half of dorsal and ventral margins; tonofibrillary platelets medium to dark brown. Remainder of prothorax with brown granules dorsally and laterally, granules indistinct ventrally; hypodermal pigmentation yellowish white; tonofibrillary platelets yellowish white, shiny; pinacula light brown. Mesothorax, metathorax and abdomen with brown granules dorsally and laterally, granules indistinct ventrally; pinacula brown dorsally, paler brown to indistinct laterally and ventrally; tonofibrillary platelets yellowish white, shiny. Fused D2 pinacula of abdominal segment 9 yellow. Anal shield yellow mesally, brown laterally. Mesothoracic SD1 pinaculum forming ring, dark brown with large pale center.

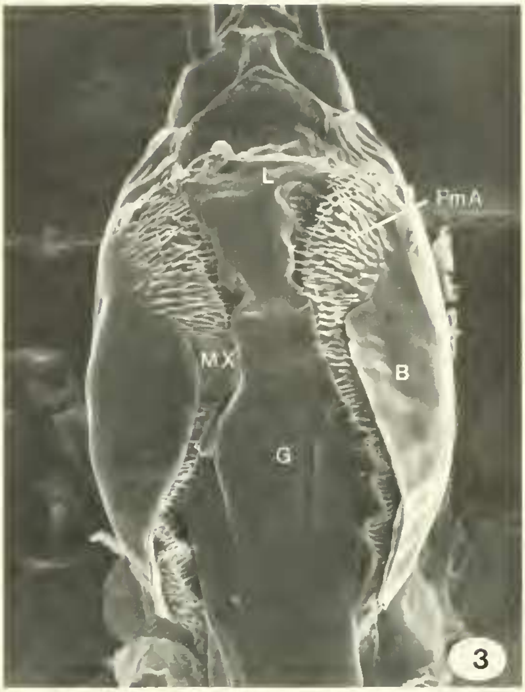


Fig. 3. Hypopharynx of *D. disclusa*, dorsal aspect (300 ×): PmA, premaxillulary area; L, lingua; MX, lobes of the maxillulae; G, gorge of the maxillulae; B, blade of the maxillulae.

Eighth abdominal SD1 pinaculum forming ring, medium brown with small pale center. Setae brown basally, pale distally. Thoracic legs light brown laterally, yellowish white mesally. *Head:* Range of length and width respectively (in mm): 1.55–1.60, 1.88–1.95. Labrum with distal margin strongly indented. Epipharynx (Fig. 4) bare mesally from center to epipharyngeal shield, remainder with fine pale spines (lateral spines very short, in rows; mesal and basal spines longer, not in rows); epipharyngeal sclerites reddish brown; epipharyngeal shield somewhat narrow, pale brown. Hypopharynx (Fig. 10) with premaxillulary area bare; lobes of maxillulae bearing moderately slender spines; lingua bare; blades of maxillulae simple; gorge of maxillulae bare; mentum reddish brown, slightly darker anteriomesally; arms of mentum reddish brown. Spinneret slender, approximately 8.5× as long as median breadth. *Thorax:* SD1 on mesothorax 1.35 mm to 1.73 mm long. Integument of mesothorax areolate-rugose ventrade of D1&2 (Fig. 16); aerolate anterior to D1&2 (Figs. 16, 22). *Abdomen:* Seta D2 of abdominal segment 2 approximately ⅓ to ½ dorsoventral diameter of segment. SD1 of segment 8, 1.18 mm to 1.83 mm long. Crochets of abdominal prolegs biordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg.3: 42–62, seg.4: 52–56; seg.5: 54–62; seg.6: 48–64; seg.10: 43–47. Perianal region (Fig. 28) with short, slightly stout pale spines, spines dorsad of anus slightly longer and more slender than those laterad.

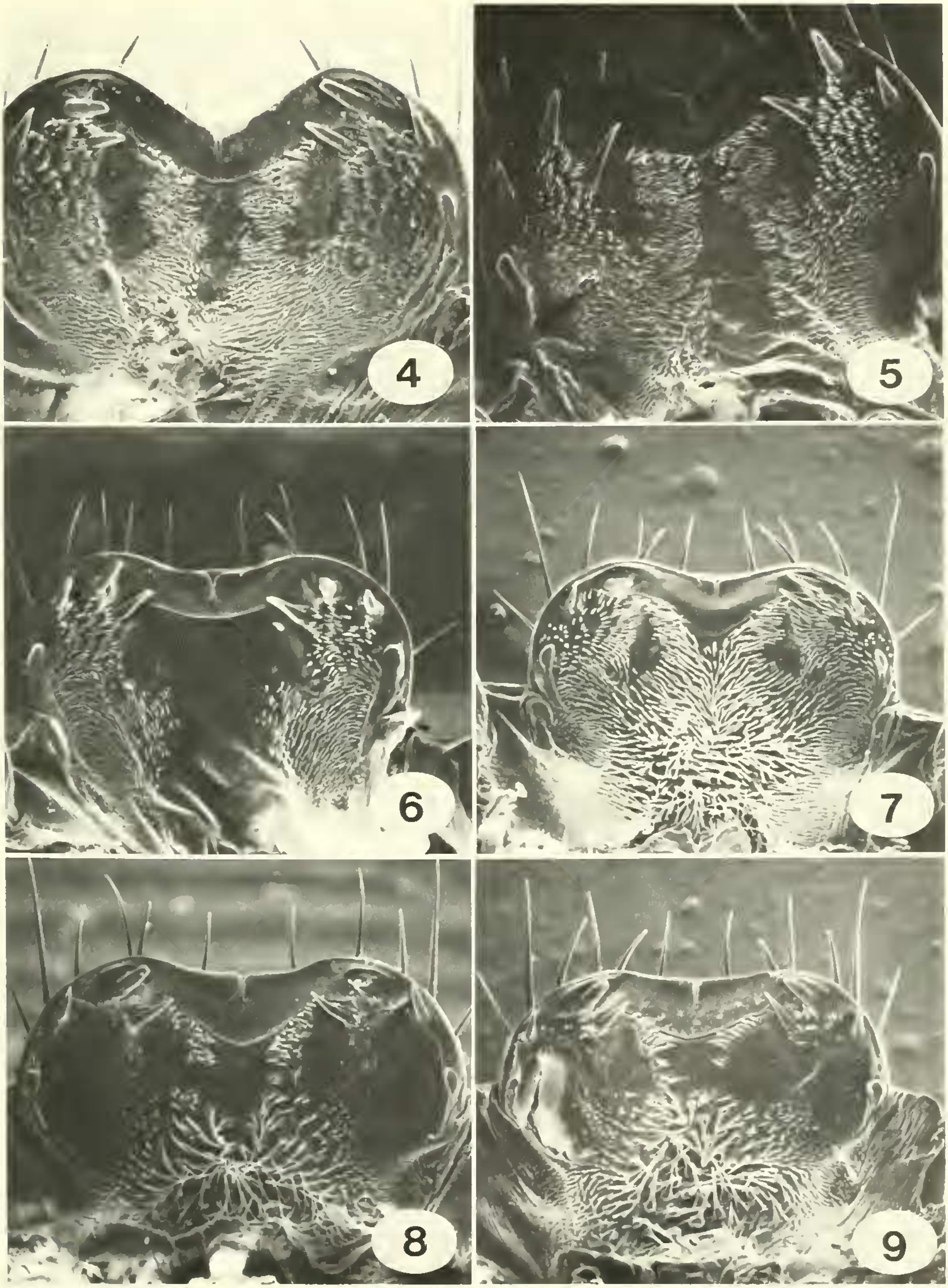
Materials examined.—Four larvae, USA N. Carolina: Mitchell Co., Bakersville, 28-X-1982, 21-VII-1983, 3-VIII-1983, W. Ayers. All larvae collected from *Abies fraseri.*

Comments.—In N.C. the larvae feed in the apical terminals and young branches of Fraser's fir, leaving a mass of frass, webbing, and needle fragments at the feeding site (Leidy and Neunzig 1986).

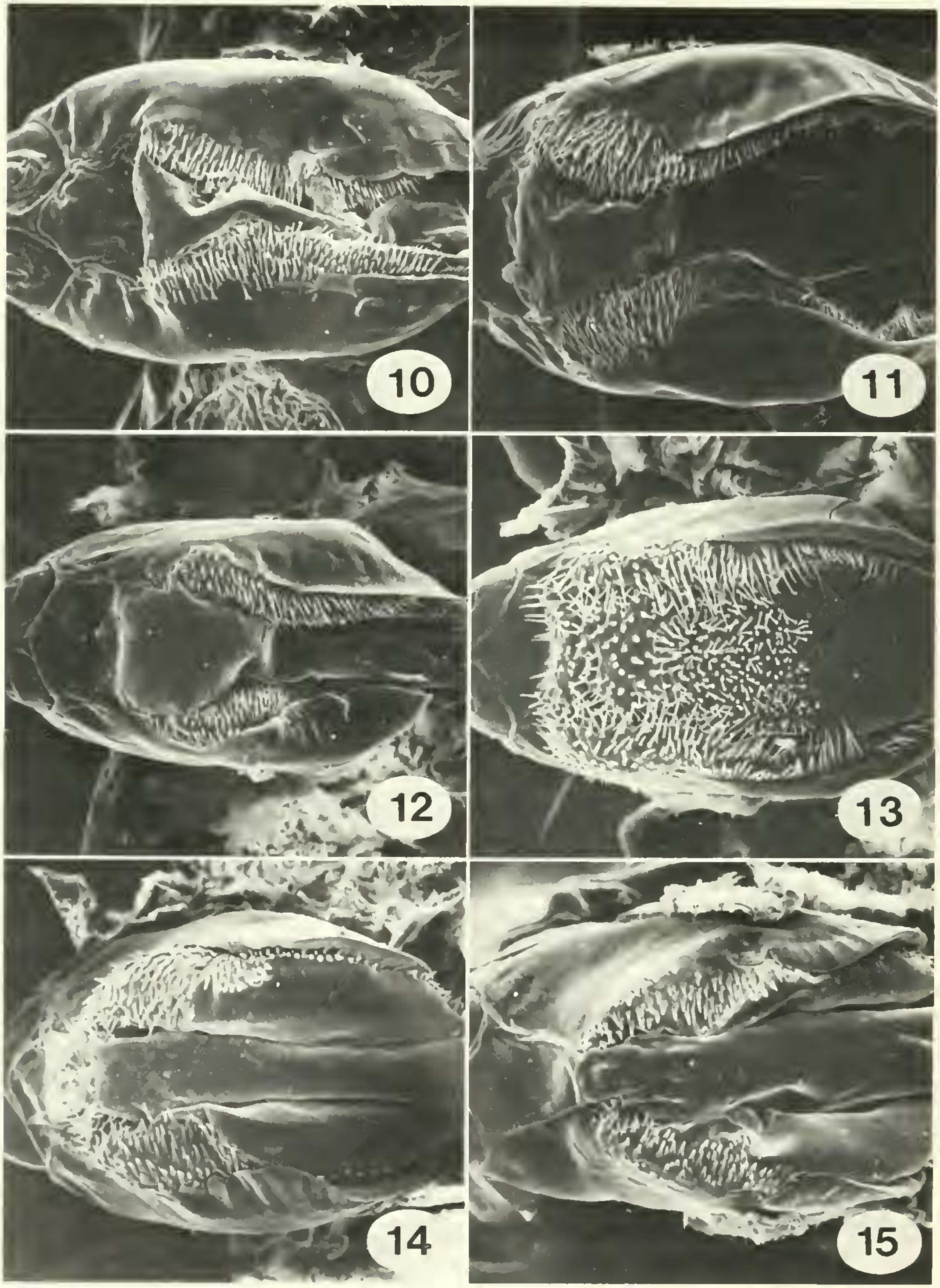
Dioryctria disclusa Heinrich
(webbing coneworm)
Figs. 5, 11, 17, 23, 29

Dioryctria disclusa Heinrich, 1953, In Farrier and Tauber, Iowa State College Journal of Science, 27: 495.

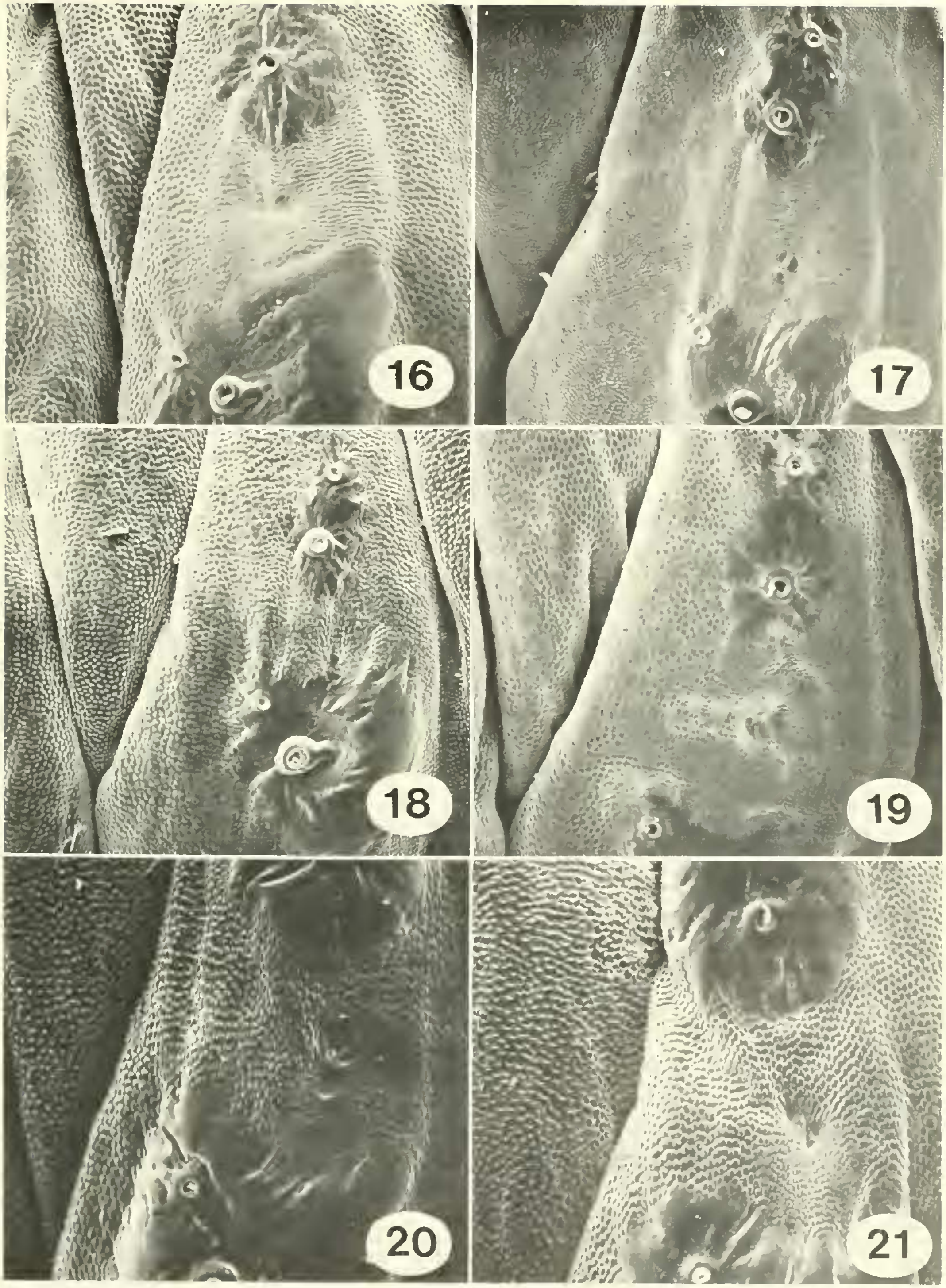
General.—Length 18.5 mm to 22.3 mm; moderately slender, at times slightly fusiform. Head reddish brown, sometimes with darker brown maculations; tonofibrillary platelets indistinct to dark brown; hypostoma dark reddish brown posteriorly, black anteriorly; antennal segments brown; mandibles reddish brown. Prothoracic shield pale yellowish brown anteriorly, pale mesally, remainder medium brown; tonofibrillary platelets dark brown. Prespiracular plate pale yellowish brown, dark brown on posterior half of dorsal and ventral margins; tonofibrillary platelets dark brown. Remainder of prothorax with gray granules dorsally and laterally; granules present ventrally but usually somewhat less prominent; hypodermal pigmentation buff; tonofibrillary platelets gray to buff, somewhat granular; pinacula light brown to buff. Mesothorax, metathorax and abdomen with gray granules dorsally, granules less distinct laterally and ventrally, or with gray granules dorsolaterally, granules less distinct mesally and laterally, appearing striped; hypodermal pigmentation buff; pinacula of mesothorax and metathorax pale brown to buff; pinacula of abdomen buff, indistinct except in contrast to granules; tonofibrillary platelets gray to buff, granular. Fused D2 pinacula of abdominal segment 9 yellowish brown. Anal shield yellowish brown. Mesothoracic SD1 pinaculum forming ring, light brown with large pale center. Eighth abdominal SD1 pinaculum forming ring, light brown with small pale center. Setae brown basally, pale distally. Thoracic legs medium to dark brown laterally, pale brown to yellowish white mesally. *Head:* Range of length



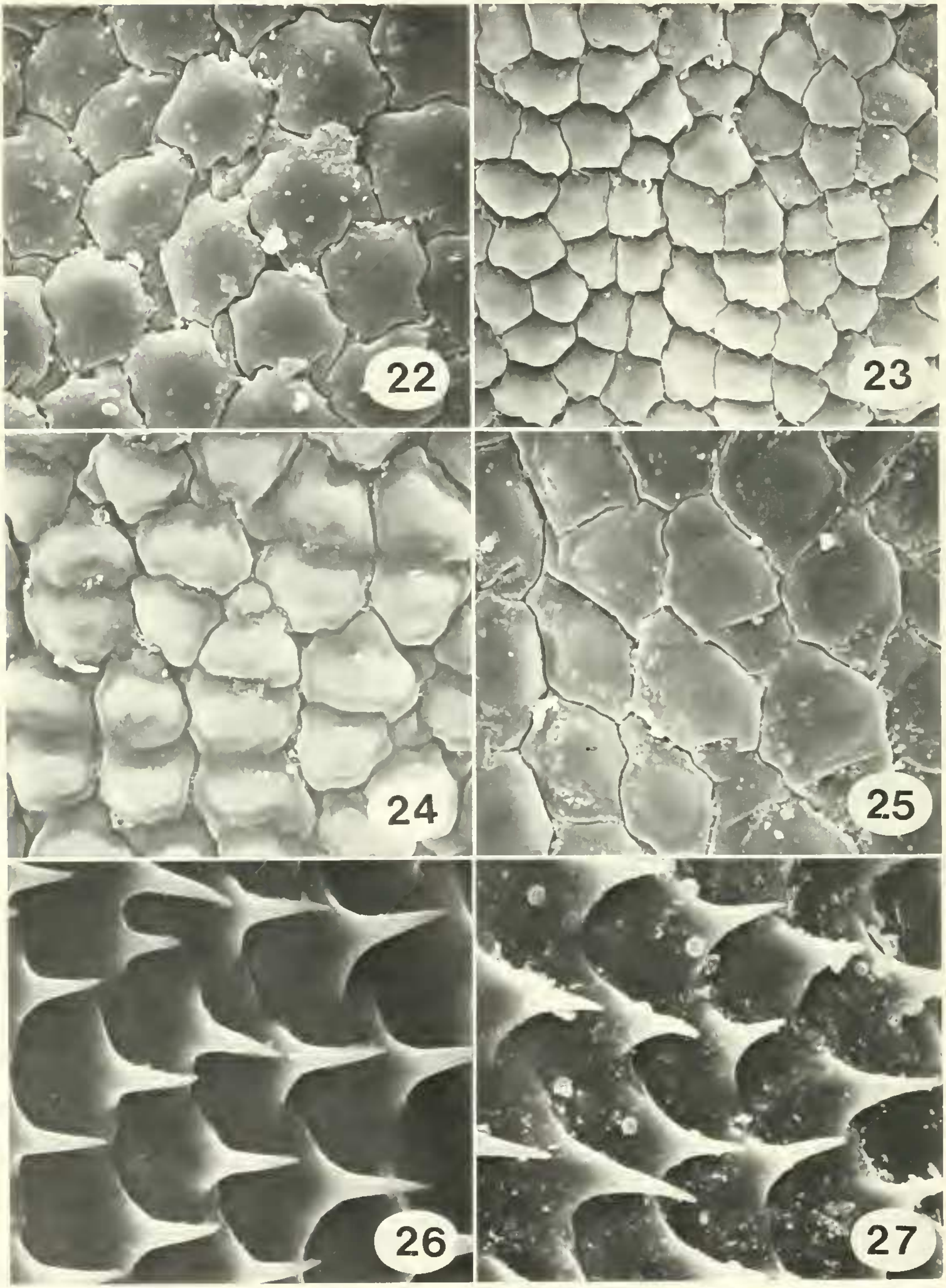
Figs. 4–9. *Dioryctria* spp. Epipharynx: 4. *D. abietivorella* (150×); 5. *D. disclusa* (150×); 6. *D. pygmaeella* (150×); 7. *D. clarioralis* (100×); 8. *D. amatella* (100×); 9. *D. taedivorella* (100×).



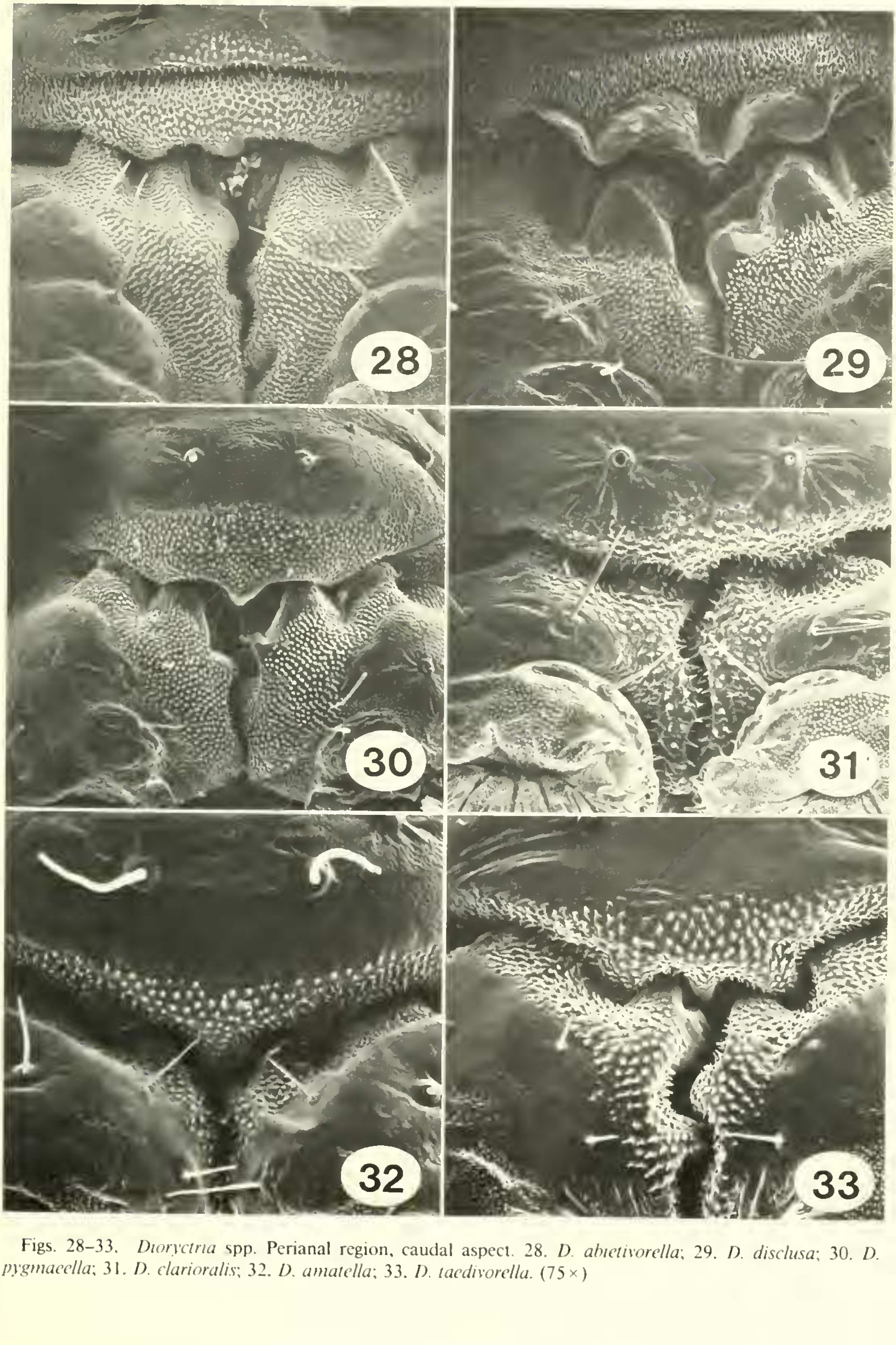
Figs. 10–15. *Dioryctria* spp. Hypopharynx, dorsal aspect: 10. *D. abietivorella* (200×); 11. *D. disclusa* (200×); 12. *D. pygmaeella* (200×); 13. *D. clarioralis* (150×); 14. *D. amatella* (150×); 15. *D. taedivorella* (150×).



Figs. 16–21. *Dioryctria* spp. Part of mesothorax including D and SD pinacula, dorsolateral aspect: 16. *D. abietivorella*; 17. *D. disclusa*; 18. *D. pygmaeella*; 19. *D. clarioralis*; 20. *D. amatella*; 21. *D. taedivorella*. (100×)



Figs. 22–27. *Dioryctria* spp. Integument of mesothorax anterior to D1&2, dorsal aspect (see Fig.1 for exact location): 22. *D. abietivorella*; 23. *D. disclusa*; 24. *D. pygmaeella*; 25. *D. clarioralis*; 26. *D. amatella*; 27. *D. taedivorella*. (1500×)



Figs. 28–33. *Dioryctria* spp. Perianal region, caudal aspect. 28. *D. abietivorella*; 29. *D. disclusa*; 30. *D. pygmaeella*; 31. *D. clarioralis*; 32. *D. amatella*; 33. *D. taedivorella*. (75×)

and width respectively (in mm): 1.43–1.60, 1.60–1.78. Labrum with distal margin moderately indented. Epipharynx (Fig. 5) bare mesally to base and anterior to epipharyngeal sclerites; bearing short fine pale spines laterally and mesad of epipharyngeal sclerite; epipharyngeal sclerite indistinct; epipharyngeal shield narrow, reddish brown. Hypopharynx (Fig. 11) with premaxillulary area and lobes of maxillulae bearing long, moderately slender spines; lingua bare; blades of maxillulae simple; gorge of maxillulae bare; mentum reddish brown, black anteriomesally; arms of mentum reddish brown. Spinneret slender, approximately 7× as long as median breath. *Thorax:* SD1 on mesothorax 1.13 mm to 1.55 mm long. Integument of mesothorax areolate ventrad of D1&2 (Fig. 17), squamiform anterior to D1&2 (Figs. 17, 23). *Abdomen:* Seta D2 of abdominal segment 2 approximately ¼ dorsoventral diameter of segment. SD1 of segment 8, 1.38 mm to 2.0 mm long. Crochets of abdominal prolegs mostly biordinal, occasionally partly triordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg.3: 53–78; seg.4: 60–74; seg.5: 57–76; seg.6: 59–75; seg.10: 46–65. Perianal region (Fig. 29) with short, light brown spines, spines dorsad of anus slightly longer and more slender than those laterad.

Material examined.—Twelve larvae. USA N. Carolina: Wayne Co., nr. Princeton, 30-IV-1985, N. A. Leidy; Johnston Co., nr. Princeton, 30-IV-1985, N. A. Leidy; Wayne Co., Goldsboro, 30-VI-1985, N. A. Leidy; Johnston Co., Clayton, 2-V-1985, N. A. Leidy; Bladen Co., Elizabethtown, 13-V-1985, N. A. Leidy; Wake Co., New Hill, 24-V-1984, Leidy & Richmond; Wake Co., Apex, 21-V-1984, N. A. Leidy. All larvae collected from *Pinus taeda.*

Comments.—The length of seta SD1 of the mesothorax and abdomen is at considerable variance from that reported by Neunzig et al. (1964) and figured by Farrier and Tauber (1953). It is consistent, however, in larvae from several dates and localities collected in 1985 and 1986. Larvae feed in ovulate cones leaving a mass of frass and webbing over the entry hole.

Dioryctria pygmaeella Ragonot
(baldcypress coneworm)
Figs. 6, 12, 18, 24, 30

Dioryctria pygmaeella Ragonot, 1887, Diagnoses of North American Phycitidae and Galleriidae, 5.

General.—Length 11.1 mm to 15.1 (see comments); moderately slender, at times slightly fusiform. Head brown with darker brown maculations or uniformly dark brown; tonofibrillary platelets dark brown to indistinct; hypostoma dark brown; antennal segments dark brown; mandibles dark reddish brown. Prothoracic shield pale anteriorly and mesally, remainder light to medium brown with darker maculations or uniformly dark brown; tonofibrillary platelets dark brown to indistinct. Prespiracular plate light to dark brown; tonofibrillary platelets dark brown to indistinct. Remainder of prothorax with indistinct granules; hypodermal pigmentation pale yellow overlain with longitudinal white and pinkish orange stripes laterally, pale yellow ventrally; tonofibrillary platelets indistinct; pinacula dark brown at base of setae, remainder indistinct. Mesothorax, metathorax and abdomen with indistinct granules; hypodermal pigmentation pale yellow overlain with longitudinal white and pinkish orange stripes dorsally and laterally, pale yellow ventrally; pinacula dark brown at base of setae, remainder indistinct; tonofibrillary platelets indistinct. Fused D2 pinacula of abdominal segment 9 dark brown at base of setae, remainder pale yellowish brown to indistinct. Anal shield dark brown at base of setae, remainder pale yellowish brown. Mesothoracic SD1 pinaculum forming ring, dark brown with large pale center. Eighth abdominal SD1 pinaculum forming ring, dark brown with large pale center. Setae brown basally, pale distally. Thoracic legs dark brown. *Head:* Range of length and width respectively (in mm): 1.13–1.25, 1.28–1.55. Labrum with distal margin moderately indented. Epipharynx bare mesally to base, bearing short fine pale spines laterally (Fig. 6), occasionally bare mesad of epipharyngeal sclerites, bearing short fine pale spines mesally at base and laterally; epipharyngeal sclerites indistinct; epipharyngeal shield narrow, pale distally, brown proximally and mesally. Hypopharynx with premaxillulary area bare; lobes of maxillulae bearing moderately slender spines distally, longer slender spines proximally; lingua bare; blades of maxillulae simple; gorge of maxillulae bare (Fig. 12), occasionally bearing slender spines distally; mentum brown, darker anteriomesally; arms of mentum brown. Spinneret slender, approximately 6× as long as median breadth. *Thorax:* SD1 on mesothorax 1.25 mm to 1.60 mm long. Integument of mesothorax areolate-rugose ventrad of D1&2 (Fig. 18); tuberculate-squamiform anterior to D1&2 (Figs. 18, 24). *Abdomen:* Seta D2 of abdominal segment 2 approximately ⅓ the dorsoventral diameter of the segment. SD1 of segment 8, 1.30 mm to 1.90 mm long. Crochets of abdominal prolegs partly biordinal, partly triordinal, arranged in a circle. Number of crochets of abdominal prolegs: seg.3: 48–68; seg.4: 50–69; seg.5: 50–70; seg.6: 50–72; seg.10: 33–49. Perianal region with short, peg-like pale to light brown spines (Fig. 30).

Material examined.—Fourteen larvae. USA N. Carolina: Currituck Co., Coinjock, 14-VII-1986, N. A. Leidy; Currituck Co., Coinjock, 17-VIII-1978, L. Grimes; Bladen Co., Singletary Lake State Park (collected by permit) 23-VII-1985, N. A. Leidy. All larvae collected from *Taxodium distichum.*

Comments.—The epipharynx and hypopharynx show considerable variation in spinulation; however, both variations occur in larvae from the same site and collection date, and other larval characters and associated reared adults give no reason to suspect two separate species. Three larvae had an overall length of 11.1 mm to 11.8 mm. These larvae were borrowed material which had been stored for several years in 80% ethanol and may have dessicated and shrunk slightly. Freshly preserved larvae ranged from 12.7 mm to 15.1 mm. All larval feeding records are from bald cypress ovulate cones.

Dioryctria clarioralis (Walker)
(blister coneworm)
Figs. 7, 13, 19, 25, 31

Nephopteryx (sic) *clarioralis* Walker, 1863, List of the Specimens of Lepidopterous Insects in the Collection of the British Museum, 27: 54.

General.—Length 20.1 mm to 20.2 mm, moderately slender. Head reddish brown with dark brown maculations (uniformly dark brown); tonofibrillary platelets dark brown (indistinct); hypostoma reddish brown (dark brown); antennal segments brown; mandibles reddish brown. Prothoracic shield pale anteriorly and mesally, remainder pale yellowish brown (dark brown); tonofibrillary platelets dark brown. Prespiracular plate pale yellowish brown (dark brown, pale on anterior and ventral margins); tonofibrillary platelets dark brown. Remainder of prothorax with gray granules dorsally and laterally, granules present ventrally but somewhat less prominent; hypodermal pigmentation yellowish white, tonofibrillary platelets gray, somewhat granular; pinacula yellowish white and indistinct to pale brown. Mesothorax, metathorax and abdomen with gray granules dorsally, granules less distinct laterally and ventrally; hypodermal pigmentation yellow overlain with pale rose giving an overall pale orange appearance; pinacula pale yellow, indistinct (pale brown); tonofibrillary platelets pale gray, somewhat granular. Fused D2 pinacula of abdominal segment 9 pale yellow. Anal shield pale yellow. Mesothoracic SD1 pinaculum forming incomplete ring, pale yellow (brown) with large pale center. Eighth abdominal SD1 pinaculum forming ring, pale yellow (brown) with large pale center. Setae brown basally, pale distally. Thoracic legs pale brown (dark brown) laterally, yellowish white mesally. *Head:* Length and width respectively (in mm): (specimen 1) 1.62, 1.75; (specimen 2) 1.50, 1.60. Labrum with distal margin moderately indented. Epipharynx (Fig. 7) bearing short slender pale spines laterally, longer slender pale spines mesally; epipharyngeal sclerites pale reddish brown; epipharyngeal shield large, pale brown. Hypopharynx (Fig. 13) with premaxillulary area, lobes of maxillulae, lingua, and gorge of maxillulae anteriorly bearing pale spines, spines somewhat short mesally, longer laterally and anteriorly; gorge of maxillulae bare posteriorly; blades of maxillulae simple; mentum brown, darker anteriomesally; arms of mentum brown. Spinneret slender, approximately 6 × as long as median breadth. *Thorax:* SD1 on mesothorax 0.60 mm to 0.67 mm long. Integument of mesothorax areolate ventrad of D1&2 (Fig. 19), areolate anterior to D1&2 (Figs. 19, 25). *Abdomen:* Seta D2 of abdominal segment 2 approximately $1/7$ dorsoventral diameter of segment. SD1 of segment 8, 0.60 mm to 0.73 mm long. Crochets of abdominal prolegs mostly triordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg. 3: 76–80; seg. 4: 68–70; seg. 5: 76–78; seg. 6: 80–82; seg. 10: 49–51. Perianal region (Fig. 31) with coarse pale (medium brown) spines.

Material examined.—Two larvae. USA N. Carolina: Wake Co., 27-VI-1986, N. A. Leidy; Wayne Co., Goldsboro, 14-I-1987, J. A. Smith. Larvae collected from *Pinus taeda*.

Comments.—Only two larvae of *D. clarioralis* were obtained. One larva was reared by placing a gravid light-trapped female in a sleeve cage over a branch of *P. taeda* bearing developing ovulate cones and allowing her to lay eggs. This larva forms the basis of the above description. A second larva obtained in Jan. 1987, from damaged host material has been included but varies considerably from the first larva in coloration of the pigmented, sclerotized structures. It is also more slender but head capsule and setal measurements indicate a last-instar larva. Variations are indicated parenthetically above. The differences in size and pigmentation are probably due to the colder average temperature at which this larva developed. Larvae feed in ovulate cones or branch terminals leaving a blister of resin-coated webbing and frass over the entry hole.

Dioryctria amatella (Hulst)
(southern pine coneworm)
Figs. 8, 14, 20, 26, 32

Nephopteryx (sic) *amatella* Hulst, 1878, Entomologica Americana, 3(7): 131.

General.—Length 19.5 mm to 25.4 mm; moderately robust. Head light to medium reddish brown; tonofibrillary platelets indistinct; hypostoma reddish brown; antennal segments brown; mandibles dark reddish brown. Prothoracic shield pale brown to yellow anteriorly, pale brown to brown mesally with pale longitudinal stripe, remainder dark brown; tonofibrillary platelets dark brown. Prespiracular plate dark brown, tonofibrillary platelets black, shiny. Remainder of prothorax with brown granules dorsally and laterally, granules present ventrally, but indistinct; hypodermal pigmentation greenish white to pale green ventrad of tonofibrillary platelets, remainder greenish white to pale green overlain with rose; tonofibrillary platelets black, shiny; pinacula brown to indistinct. Mesothorax, metathorax and abdomen with brown granules dorsally, granules less distinct laterally, indistinct ventrally; hypodermal pigmentation greenish white to pale green ventrad of tonofibrillary platelets, remainder greenish white to pale green heavily overlain with rose dorsally, rose less distinct laterally and ventrally; pinacula dark brown dorsally to pale brown ventrally; tonofibrillary platelets black, shiny. Fused D2 pinacula of abdominal segment 9 pale to medium yellowish brown. Anal shield pale to medium yellowish brown. Mesothoracic SD1 pinaculum forming ring, dark brown with minute pale center. Eighth abdominal SD1 pinaculum not forming ring, unicolorous dark brown. Setae brown basally, pale distally. Thoracic legs pale mesally, dark laterally. *Head:* Range of length and width respectively (in mm): 1.62–2.10, 2.05–2.35. Labrum with distal margin slightly indented. Epipharynx (Fig. 8) at base with numerous pale, stout spines mesally; epipharyngeal sclerite pale reddish brown; epipharyngeal shield large, dark brown. Hypopharynx (Fig. 14) with premaxillulary area, lingua and lobes of maxillulae bearing coarse spines; blades of maxillulae simple; gorge of maxillulae bare; mentum reddish brown, dark brown anteriomesally extending anteriorly to lingua; arms of mentum brown. Spinneret relatively stout, approximately 5× as long as median breadth. *Thorax:* SD1 on mesothorax 0.75 mm to 1.02 mm long. Integument of mesothorax tuberculate ventrad of D1&2 (Fig. 20); spinose anterior to D1&2 (Figs. 20, 26). *Abdomen:* Seta D2 of abdominal segment 2 approximately ¼ dorsoventral diameter of segment. SD1 of segment 8, 0.77 mm to 0.97 mm long. Crochets of abdominal prolegs mostly biordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg. 3: 52–64; seg. 4: 54–62; seg. 5: 46–64; seg. 6: 48–60; seg. 10: 29–39. Perianal region with coarse pale spines (Fig. 32).

Material examined.—Sixteen larvae. USA N. Carolina: Richmond Co., Rockingham, 4-VIII-1985, 6-VIII-1986, N. A. Leidy; Moore Co., Southern Pines, 4-VIII-1985, 14-VIII-1983, N. A. Leidy; Onslow Co., Richlands, 16-VII-1985, N. A. Leidy. Larvae collected primarily from *Pinus palustris,* a few collected from *P. taeda.*

Comments.—Although the perianal spines of *D. amatella* (Fig. 32) are in size actually very similar to those of *D. taedivorella* (Fig. 33), they appear more slender when viewed with the light microscope because of their pigmentation. Larvae of the spring generation on *P. palustris* often feed within the branch terminals, leaving masses of pitch mixed with some frass over the entry hole. Later generations on *P. palustris* feed in the ovulate cones, leaving large masses of pitch mixed with frass over the entry hole. Larvae feeding in the ovulate cones of *P. taeda* were not observed to leave masses of pitch at the entry hole.

Dioryctria taedivorella Neunzig and Leidy
(loblolly pine coneworm)
Figs. 9, 15, 21, 27, 33

Dioryctria taedivorella Neunzig and Leidy, 1989, Proc. Entomological Society of Washington, 91: 321–324.

General.—Length 18.6 mm to 23.4 mm; moderately robust. Head medium to dark reddish brown occasionally with slightly darker maculations; tonofibrillary platelets indistinct; hypostoma dark reddish brown; antennal segments brown; mandibles dark reddish brown. Prothoracic shield pale yellow anteriorly and mesally, remainder dark brown, occasionally paler brown posteriorly; tonofibrillary platelets dark brown. Prespiracular plate brown to dark brown; tonofibrillary platelets black. Remainder of prothorax with dark brown granules dorsally and laterally; granules present ventrally but less prominent and pale; hypodermal pigmentation pale green ventrad of tonofibrillary platelets, remainder pale green overlain with rose; tonofibrillary platelets black, shiny; pinacula dark brown dorsally to pale brown ventrally. Mesothorax, metathorax and abdomen with dark brown granules dorsally and laterally, granules less distinct ventrally; hypodermal pigmentation pale green ventrad of tonofibrillary platelets, remainder rose; pinacula dark brown dorsally to pale brown ventrally; tonofibrillary platelets black, shiny. Fused D2 pinacula of abdominal segment 9 yellowish brown to reddish brown, occasionally darker marginally. Anal shield yellowish brown to reddish brown mesally, reddish brown to dark brown laterally. Mesothoracic SD1 pinaculum forming ring dark brown with minute, pale center. Eighth abdominal SD1 pinaculum not forming ring, unicolorous dark brown. Setae brown basally, pale distally. Thoracic legs pale mesally, dark brown laterally. *Head:* Range of length and width respectively (in mm): 1.62–1.80, 1.95–2.18. Labrum with distal margin slightly indented. Epipharynx (Fig. 9) at base with numerous dark reddish brown tipped, stout spines mesally; epipharyngeal sclerites reddish brown; epipharyngeal shield large, dark reddish brown, nearly black slightly paler mesally. Hypopharynx (Fig. 15) with premaxillulary area and lobes of maxillulae bearing coarse spines; lingua bare to a few spines; blades of maxillulae simple; gorge of maxillulae bare; mentum reddish brown, black anteriomesally, extending anteriorly to lingua; arms of mentum reddish brown. Spinneret stout, approximately 4× as long as median breadth. *Thorax:* SD1 on mesothorax 0.62 mm to 0.87 mm long. Integument of mesothorax tuberculate-rugose ventrad of D1&2 (Fig. 21); spinose anterior to D1&2 (Figs. 21, 27). *Abdomen:* Seta D2 of abdominal segment 2 approximately ⅕ dorsoventral diameter of segment. SD1 of segment 8, 0.70 mm to 0.82 mm long. Crochets of abdominal prolegs mostly biordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg. 3: 42–60; seg. 4: 46–62; seg. 5: 39–60; seg. 6: 45–64; seg. 10: 35–49. Perianal region (Fig. 33) with coarse, dark tipped spines.

Material examined.—Seventeen larvae. USA N. Carolina: Onslow Co., Maysville, 25-VI-1985, Leidy & Lodge; Wayne Co., Goldsboro, 16-VII-1985, N. A. Leidy; Granville Co., Lewis, 18-VII-1985, N. A. Leidy; Onslow Co., Richlands, 16-VII-1985, N. A. Leidy; Robeson Co., Lumberton, 27-VII-1983, N. A. Leidy; Lenoir Co., Kinston, 14-VII-1985, N. A. Leidy; Robeson Co., Lumberton, 22-VII-1985, Leidy & Maynor; Robeson Co., Lumberton, 9-VII-1986, Leidy & Hardin. Larvae collected from *Pinus taeda.*

Comments.—Larvae feed in ovulate cones, occasionally leaving small amounts of resin and frass at the entry hole. Damaged cones turn brown before maturing and do not open.

Discussion.—New information on the larvae of *Dioryctria,* particularly with respect to spinulation of the trophi and perianal region, and the texture of the integument was revealed using SEM. The spines of the epipharynx of *D. pygmaeella* (Fig. 6) and *D. disclusa* (Fig. 5) were easily observed using SEM, but difficult to see with the light microscope, because they lack strong pigmentation. Neunzig et al. (1964), using conventional methods, did not observe these spines. Similarly, SEM revealed numerous spines on the lobes of the maxillulae of *D. pygmaeella* (Fig. 12) although Neunzig et al. (1964) described the hypopharynx of *D. pygmaeella* as "bare or with a few indistinct spines." The perianal region of *D. pygmaeella* was also described by Neunzig et al. (1964) as "lacking distinct spines"; however, SEM showed considerable spinulation (Fig. 30). Additionally, Neunzig et al. (1964) separated *D. amatella* (Fig. 32) and *D. taedivorella* (Fig. 33) (as *zimmermani*) partly on the basis of the appearance of the perianal spines; however, electron micrographs of this region in the two species showed little difference. The variation observed with the light microscope is apparently due to pigmentation, not relative size of the spines.

The appearance of other structures also varied depending on the method of observation. The epipharyngeal shield was apparent with either method, but the epipharyngeal sclerites, quite prominent under the light microscope on some species because of their pigmentation, were not distinct using SEM. Their location could be established in species with the epipharynx heavily spinose, such as *D. clarioralis* (Fig. 7), because of the absence of spines on the sclerites. In species such as *D. amatella* (Fig.

8), however, with only a few spines in the general area, there is no real indication of a structure.

The tonofibrillary platelets of the mesothorax also appeared quite dissimilar depending on the method of observation. Those of *D. taedivorella* (Fig. 21) were apparent using SEM because of their indentation and difference in texture from the surrounding integument, but they are even more striking under the light microscope because of their black pigmentation. In contrast, the tonofibrillary platelets of *D. disclusa* (Fig. 17) were more distinct using SEM than in light microscopy.

SEM also made more apparent major variation in the texture of the integument. The mesothorax anterior to setae D1&2 of *D. amatella* (Fig. 26) and *D. taedivorella* (Fig. 27) is spinose, whereas it ranges from areolate in *D. abietivorella* (Fig. 22) and *D. clarioralis* (Fig. 25) to squamiform in *D. disclusa* (Fig. 23) and tuberculate-squamiform in *D. pygmaeella* (Fig. 24).

Mutuura and Munroe (1972, 1974) placed the adults of *Dioryctria* in eight species groups. Most of the species which we studied were assigned (Mutuura and Munroe 1972, 1974, 1979) to four of these as follows: abietella group: *D. abietivorella*; auranticella group: *D. disclusa*; baumhoferi group: *D. pygmaeella*; and zimmermani group: *D. amatella*. *D. clarioralis* and *D. taedivorella* were not included by Mutuura and Munroe, but obviously the former belongs to the baumhoferi group and the latter to the zimmermani group. Our study of *Dioryctria*, although treating relatively few species, gives evidence that most of the larvae can also be placed in the proposed groups. Both species of the zimmermani group have very similar spinulation of the epipharynx (Figs. 8, 9), hypopharynx (Figs. 14, 15), and perianal region (Figs. 32, 33), as well as similar integumental texture (Figs. 26, 27). Additionally, each has black tonofibrillary platelets and a unicolorous SD1 pinaculum on the eighth abdominal segment. The remaining species can be readily separated from one another as larvae. There are distinct differences in the texture of the integument of *D. abietivorella* (Fig. 22) and *D. disclusa* (Fig. 23). In addition, the pigmentation of the D1 and D2 pinacula of the abdominal segments, and the length of seta D2 of the abdominal segments further separate these two species. As mentioned, *D. pygmaeella* has been placed in the baumhoferi group. Mutuura and Munroe (1972) noted, however, that their placement of *D. pygmaeela* was tentative because of differences in the male genitalia. Examination of the larval characters also casts doubt on the placement of *D. pygmaeella* in the baumhoferi group. Variation in the spinulation of both the hypopharynx (Figs. 12, 13) and perianal region (Figs. 30, 31) of *D. pygmaeella* and *D. clarioralis* is considerable. Differences are also found in the texture of the integument (Figs. 24, 25). Blanchard and Knudson (1983) recently described a new species from Texas, *D. caesirufella*, which they feel is most closely allied with *D. pygmaeella*. Although larvae of *D. caesirufella* were not available for this study, the dissimilarity of the larvae of *D. pygmaeella* and *D. clarioralis* suggest that *D. pygmaeella* may be better placed with *D. caesirufella* in a new species group, rather than in the baumhoferi group.

KEY TO LAST-INSTAR LARVAE OF EASTERN NORTH AMERICAN SPECIES OF *DIORYCTRIA*

1. Tonofibrillary platelets of abdomen pale, differing in texture from, or only slightly darker than, integument; pinaculum SD1 of 8th abdominal segment forming ring with pale center; integument not spinose anterior to D1&2 of mesothorax (Figs. 16–19, 22–25) . . . 2
– Tonofibrillary platelets of abdomen black, shiny; pinaculum SD1 of 8th abdominal segment not forming ring, unicolorous dark brown; integument spinose anterior to D1&2 of mesothorax (Figs. 20, 21, 26, 27) . . . 5
2. Pinacula D1 & D2 of abdomen brown, at least at base of setae; seta D2 of abdominal segments long, ⅓ to ½ dorsoventral diameter of segment 3

– Pinacula D1 & D2 of abdomen usually pale, appearing lighter than surrounding integument; seta D2 of abdominal segments short, ⅓ to ¼ dorsoventral diameter of segment 4

3. Tonofibrillary platelets yellowish white, shiny, distinct from integument; pinaculum SD1 of 8th abdominal segment with small pale center; labrum with distal margin distinctly indented (Fig. 4); overall length approximately 20 mm .... *abietivorella*

– Tonofibrillary platelets indistinct; pinaculum SD1 of 8th abdominal segment with large pale center; labrum with distal margin weakly indented (Fig. 6); overall length approximately 13 mm .... *pygmaeella*

4. Pinaculum SD1 of 8th abdominal segment with small pale center; pinaculum SD1 of mesothorax forming complete ring; seta D2 of abdominal segments approximately ¼ dorsoventral diameter of segment; lingua and gorge of mentum bare (Fig. 11) .... *disclusa*

– Pinaculum SD1 of 8th abdominal segment with large pale center; pinaculum SD1 of mesothorax forming incomplete ring; seta D2 of abdominal segments approximately ⅓ dorsoventral diameter of segment; lingua and gorge of mentum spinose (Fig. 13) ...... *clarioralis*

5. Perianal region with pale brown tipped spines, spines appearing slender at low magnification; epipharynx with pale, coarse spines at base; hypopharynx with lingua bearing numerous coarse spines (Fig. 14) .... *amatella*

– Perianal region with dark reddish brown tipped spines, spines appearing stout at low magnification; epipharynx with dark reddish brown tipped coarse spines at base; hypopharynx with lingua bare or bearing at most a few coarse spines (Fig. 15) .... *taedivorella*

ACKNOWLEDGMENTS

We thank the following people who helped in obtaining study material either by providing specimens, assisting in the actual collection, or allowing access to their land or land under their supervision: W. Ayers, Roan Valley Tree Farm, Mitchell Co., N.C.; H. Barron, Edwards State Forest, Morganton, N.C.; L. Grimes, Meredith College, Raleigh, N.C.; T. Hardin, Federal Paper Board Co., Lumberton, N.C.; L. Jervis, N.C. State Univ., Raleigh, N.C.; J. Killian, Mary Washington College, Fredricksburg, Va.; D. Lodge, formerly N.C. State Univ., Raleigh, N.C.; M. Maynor, Federal Paper Board Co., Lumberton, N.C.; N. Potts, Highlands, N.C.; J. Richmond, N.C. State Univ., Raleigh, N.C.; D. Rogers, Edwards State Forest, Morganton, N.C.; D. Sparkman, Federal Paper Board Co., Lumberton, N.C.; D. Stephan, N.C. State Univ., Raleigh, N.C.; B. Taylor, N.C. Div. of Parks and Recreation, Raleigh, N.C.; G. Turner, Claridge State Forest, Goldsboro, N.C.; and W. Wicks, Champion Intl. Corp., Deppe, N.C.

The NCSU College of Agriculture and Life Sciences, Center for Electron Microscopy provided financial assistance for use of the scanning electron microscope through minigrants. We also thank C. Giles, formerly CALS Center for Electron Microscopy, NCSU, Raleigh, N.C., and L. Grimes, Meredith College, Raleigh, N.C., for their assistance in specimen preparation techniques. This paper is part of a thesis submitted by N. A. Leidy in partial fulfillment of the requirements of the M.S. degree in entomology, North Carolina State University, Raleigh, N.C., and is paper No. 11471 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, N.C. 27695-7643. The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Research Service of the products named, nor criticism of similar ones not mentioned.

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